



EXPLORE FLIGHT

WE'RE WITH YOU WHEN YOU FLY

NASA Update

FAA REDAC E&E Subcommittee Meeting
March 22, 2022

Barbara Esker, Deputy Director, Advanced Air Vehicles Program
NASA Aeronautics Research Mission Directorate

NASA Aeronautics – Vision for Aviation in the 21st Century



ARMD continues to evolve and execute the Aeronautics Strategy
<https://www.nasa.gov/aeroresearch/strategy>

6 Strategic Thrusts



Safe, Efficient Growth in Global Operations



Safe, Quiet, and Affordable Vertical Lift Air Vehicles



Innovation in Commercial Supersonic Aircraft



In-Time System-Wide Safety Assurance



Ultra-Efficient Subsonic Transports



Assured Autonomy for Aviation Transformation

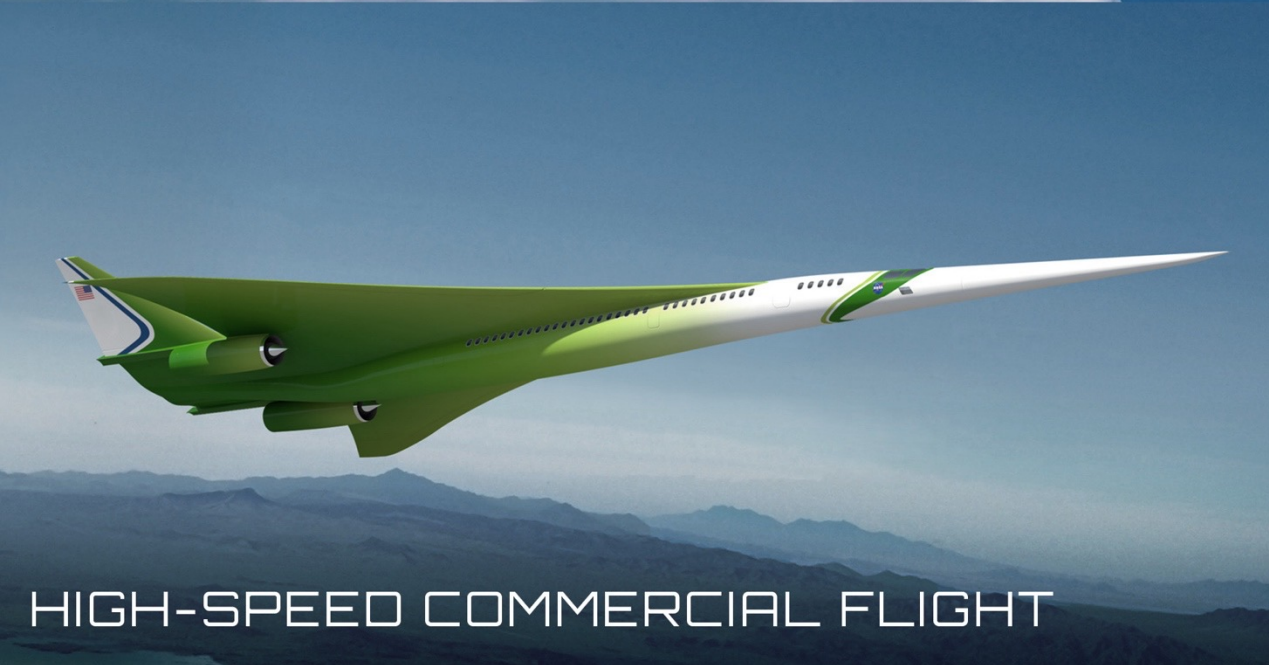
U.S. leadership for a new era of flight



ULTRA-EFFICIENT TRANSPORT



FUTURE AIRSPACE



HIGH-SPEED COMMERCIAL FLIGHT



ADVANCED AIR MOBILITY

Four Transformations for Sustainability, Greater Mobility, and Economic Growth



Supersonics

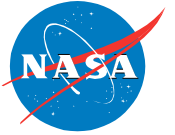


Vertical flight



Subsonic transports

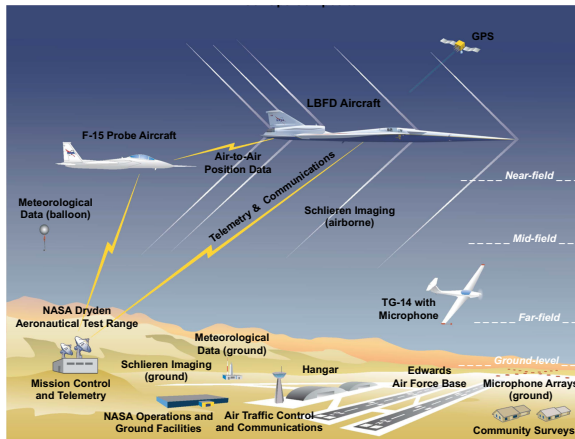
Low Boom Flight Demonstration Mission Overview



Phase 1 – Aircraft Development – *In progress 2018-22*

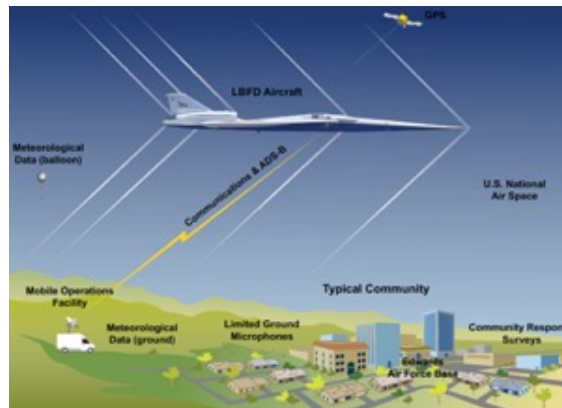
- Detailed design
- Fabrication, integration, ground test
- Checkout flights
- Subsonic envelope expansion
- Supersonic envelope expansion

**Systematic Approach Leading
to Community Testing**



Phase 2 – Acoustic Validation – *Preparation 2018-22, Execution 2022-23*

- Aircraft operations & support, range operations, support aircraft
- In-flight measurement capabilities
- Ground measurement capabilities
- Validation of X-59 boom signature and prediction tools
- Development of acoustic prediction tools for Phase 3



Phase 3 – Community Response Testing *Preparation 2020-24, Execution 2024-26*

- Aircraft operations & support, deployment
- Ground measurement capabilities
- Ground crew operations
- Noise exposure design
- Community response surveys
- Data analysis and database delivery

Low-Boom Flight Demonstrator (LBFD) Project



Phase 1 – Aircraft Development - X-59 Aircraft Build Progressing

- Good progress being made, with some challenges encountered
 - Parts manufacturing and procurement
 - COVID-19 (decreasing impact)
- Working to schedule as updated in October 2021
 - Final system checks to start in April 2022
 - First flight targeted for summer 2022



X-59 in structural load test frame



X-59 at Lockheed Martin facility in Fort Worth TX for structural testing Jan 2022

LBFD Mission - Phase 2 and 3 Status

Acoustic Measurement

- Ground Recording System being developed by Crystal Instruments, Inc
 - Initial prototypes going through extensive testing
- Progress continues on airborne acoustic measurement systems
 - CoVID-19 is slowing effort, but not yet impacting major milestones



Community Test Planning & Execution

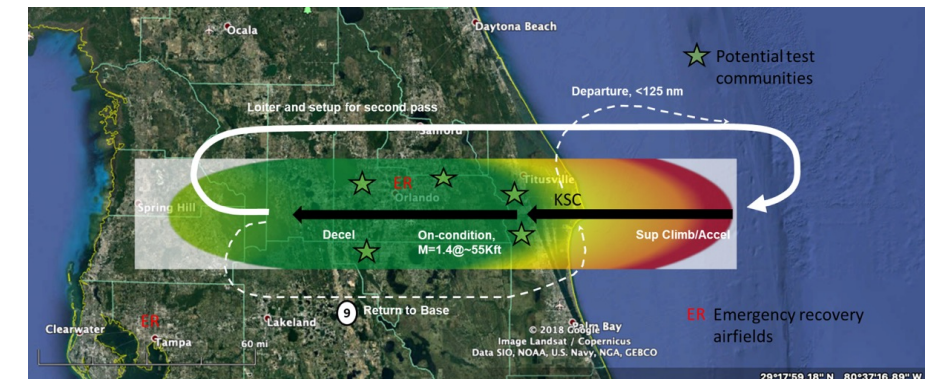
- Contractor team in place
- Test, exposure and survey plans in development
- Airfield and community selection process ongoing



International Standards Development

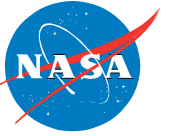
- Continued engagement with FAA/AEE, ICAO/CAEP & international research community
- International Workshop held in Dec 2021 to gather broad input and feedback on current plans for community testing including valuable insight provided by FAA/AEE from regulatory perspective

For more information, see the Dec 2021 video newsletter:
<https://www.youtube.com/watch?v=z1fDmErg098>



Representative Mission for Potential Airfield/Community Selection Studies

Commercial Supersonics LTO Noise & Prediction Uncertainty



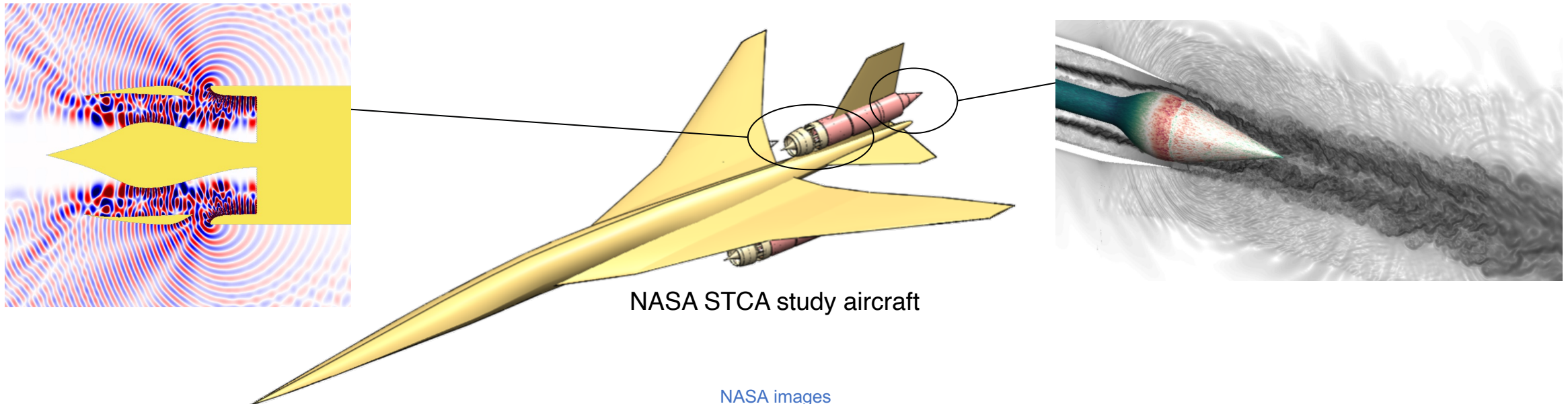
Improvements to noise prediction models used in studies of a supersonic market.

- Models based on current OEM-based aircraft designs for representative near-term aircraft.
- Data obtained by physics-based simulations, backed by model-scale tests.

Program success metric: prediction uncertainty relative to conventional fleet.

- Baseline uncertainty level quantified
- Yearly updates planned

Coordinating with industry and academia through FAA ASCENT program.



NASA images



Supersonics



Vertical flight



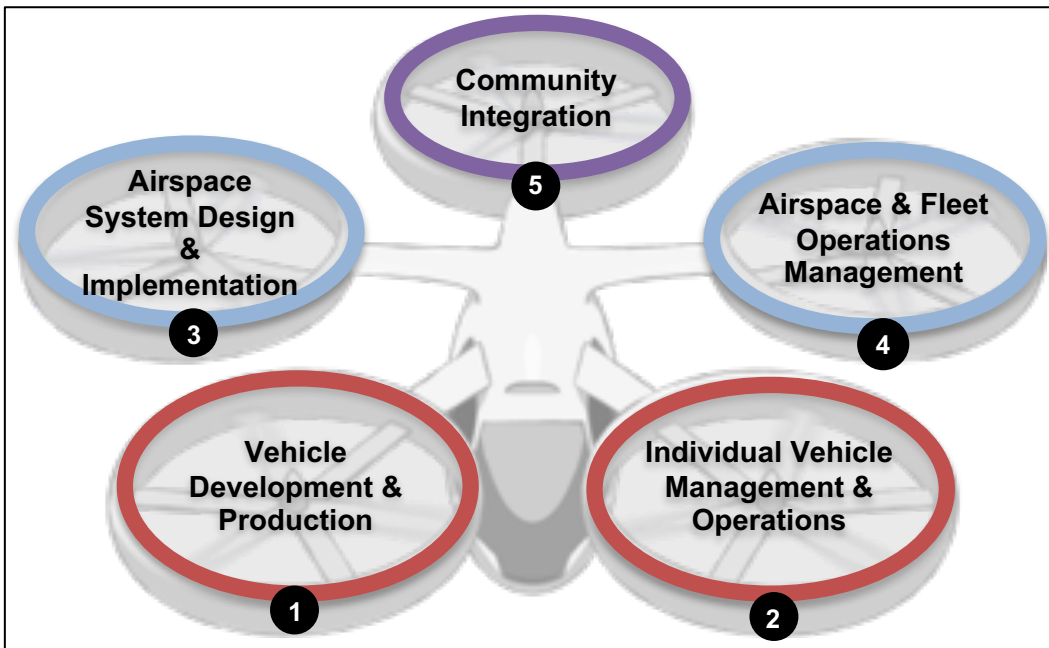
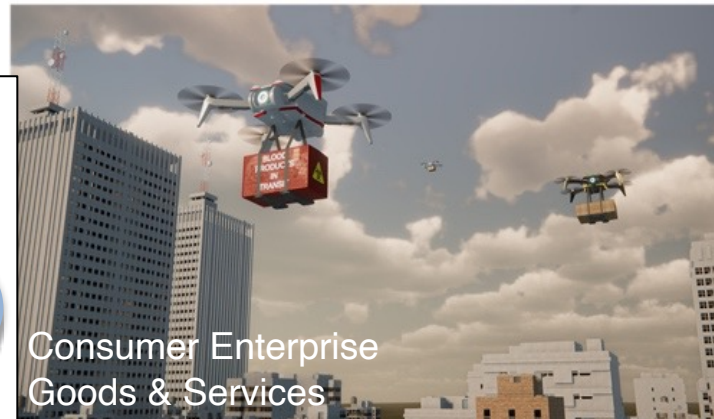
Subsonic transports

Advanced Air Mobility Mission - Vision & Framework



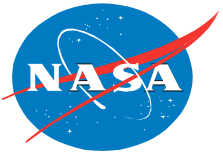
NASA AAM Vehicle Objectives

1. *Integrated Design & Operations for Noise*
2. *Integrated Aircraft-Propulsion System Performance & Reliability*
3. *Weather-Tolerant Aircraft Technologies*
4. *Survivability in Off-Nominal Conditions*
5. *Cabin Acceptability*

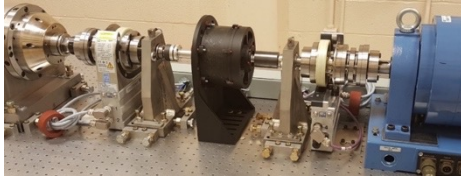


Revolutionary Vertical Lift Technologies Project

Research Focus – Vehicle Noise and Safety



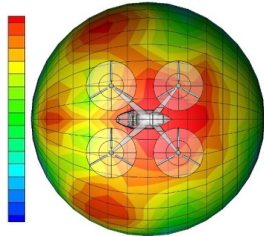
Vehicle Propulsion Reliability



Reliable & Efficient Propulsion Components for UAM

- Re-configure labs for electric propulsion testing
- Conduct initial single string tests
- Develop tools to assess motor reliability & high reliability conceptual motor design

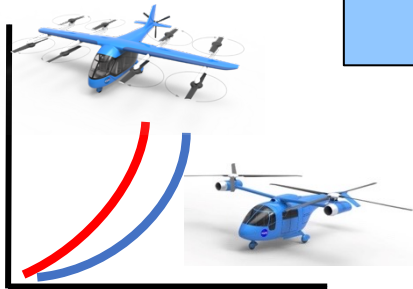
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) database for several UAM ref. configurations & trajectories
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess human response to UAM vehicles

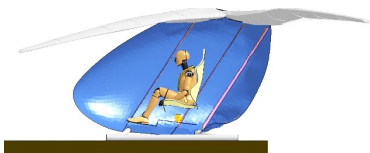
Noise and Performance



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan/conduct validation experiments
- Improve efficiency & accuracy of conceptual design tools
- Conduct high-fidelity configuration CFD for validation/reference
- Improve community transition & training for analysis tools

Safety and Acceptability

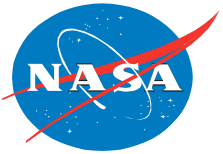


Handling and Ride Qualities

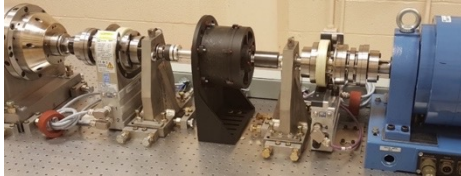
- Occupant protection & survivability
- Acceptable handling/ride qualities

Revolutionary Vertical Lift Technologies Project

FY21-23 Research Focus; Recent Technical Progress



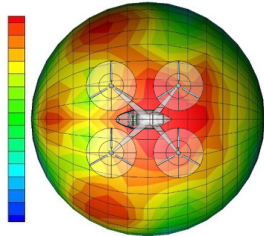
Vehicle Propulsion Reliability



Reliable & Efficient Propulsion Components for UAM

- Re-configure labs for electric propulsion
 - Conduct initial single string testing
 - Develop tools to assess motor health
- Reconfigurable Electric Propulsion Lab nearly complete; includes up to 1000VDC, 200kW source, fault insertion capability, & single-/multi-string config options. Designed to inform AS-7499 & AS-8441.

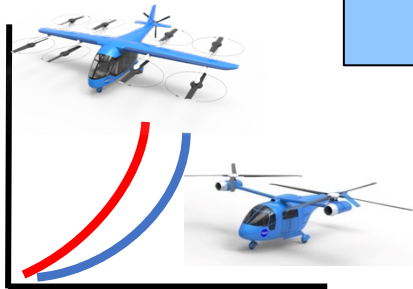
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) contours
 - Conduct Fleet Noise assessments
 - Initiate psychoacoustic testing to assess noise annoyance
- Published Gen 2 Fleet Noise Assessment - including impact of broadband noise; "Second Generation UAM Community Noise Assessment Using the FAA Aviation Environmental Design Tool," AIAA 2022-2167

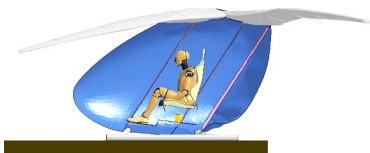
Noise and Performance



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan/conduct validation experiments
 - Improve efficiency & accuracy of conceptual design tools
 - Conduct high-fidelity configuration CFD for validation/reference
 - Improve community transition & training for analysis tools
- Presented Validation Test Plan at Acoustics Technical Working Group (Oct. 2021)

Safety and Acceptability

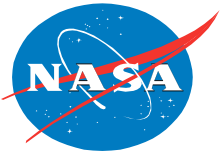


Handling and Ride Qualities

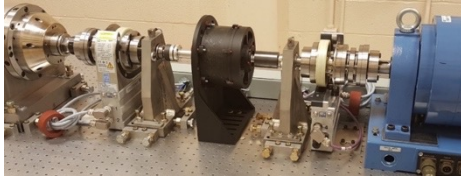
- Occupant protection & survivability
 - Acceptable handling/ride qualities
- Completed Vertical Motion Simulator evaluation of heave control & initial passenger response to UAM environment. Data analysis underway.

Revolutionary Vertical Lift Technologies Project

FY21-23 Research Focus; FAA & Standards Org Interactions



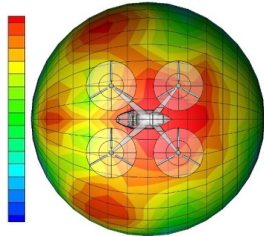
Vehicle Propulsion Reliability



Reliable & Efficient Propulsion Components for UAM

- Re-configure la
- Conduct initial
- Develop tools t
- SAE AE-7 AE-7A Permanent-Magnet Propulsion Motors & Drives
- SAE AE-7 AE-7C High Voltage DC Power Quality
- Publications: Reliability and Safety Assessment of Urban Air Mobility Concept Vehicles, NASA Contractor Reports: 2021-0017185 & 2021-0017188

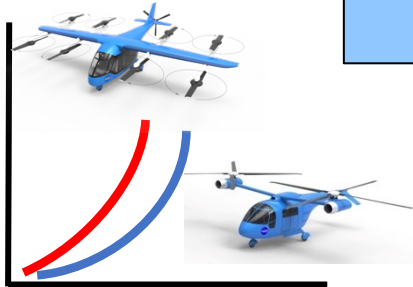
UAM Fleet Noise



UAM Operational Fleet Noise Assessment

- Generate Noise Power Distance (NPD) database
- Conduct Fleet Noise assessments
- Initiate psychoacoustic testing to assess human re
- NRSAA with FAA/AEE on Community Response
- SAE A-21 Recommended practices for measuring and modeling aircraft noise

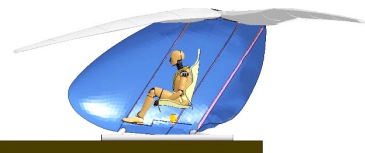
Noise and Performance



Tools to Explore the Noise & Performance of Multi-Rotor UAM Vehicles

- Plan/conduct validation experiments
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- Conduct high-fidelity configuration CFD for validation/refe
- Improve community transition & training for analysis tools
- NASA/FAA UAM Aircraft Design & Development Working Group

Safety and Acceptability



Targeted Research Areas

- Occupant protection &
- Acceptable handling/r
- ASTM D30 Committee on Composite Materials
- ASTM F44 WK68781 Means of Compliance for Dynamic Response
- ASTM F44 WK68805 Bird Strike Requirements
- SAE AC-9C Aircraft Icing Technology
- SAE G-28 Simulants for Impact and Ingestion Testing



Supersonics



Vertical flight

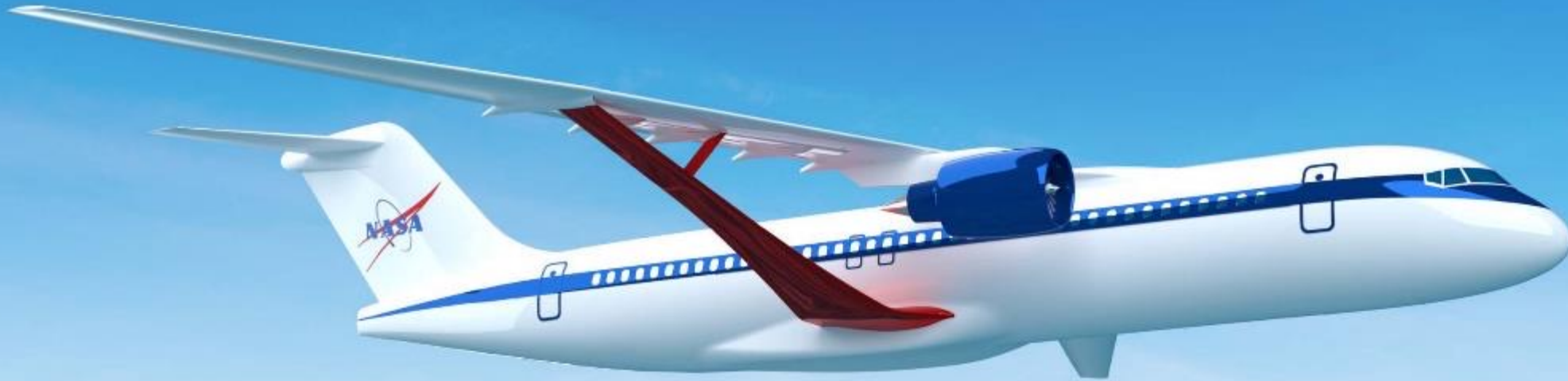


Subsonic transports

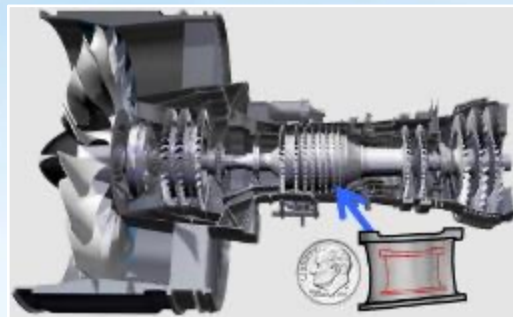
Subsonic Transport Technologies



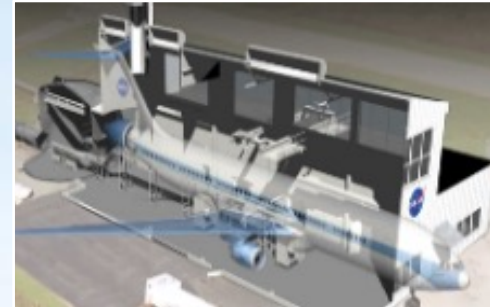
Ensure U.S. industry is the first to establish the new “S Curve” for the next 50 years of transports



Transonic Truss-Braced Wing
5-10% fuel burn benefit



Small Core Gas Turbine
5-10% fuel burn benefit



Electrified Aircraft Propulsion
~5% fuel burn and maintenance benefit



High-Rate Composite Manufacturing
4x-6x manufacturing rate increase

Subsonic Transport Technology Prioritization



NASA Aeronautics Vision
and Strategy Established

2008-2013

2014 - 2019

2020-2025

Subsonic Concept/Technology Studies
Electrified Aircraft Propulsion, Transonic Truss Braced Wing

Environmentally Responsible
Aviation (ERA) Project

Flight Demonstrator
Studies

Advanced Composites (ACP)

Next Step

Maturation and Integration of
Four Key Technologies that will
Create a New “S Curve” for
Future Subsonic Transports

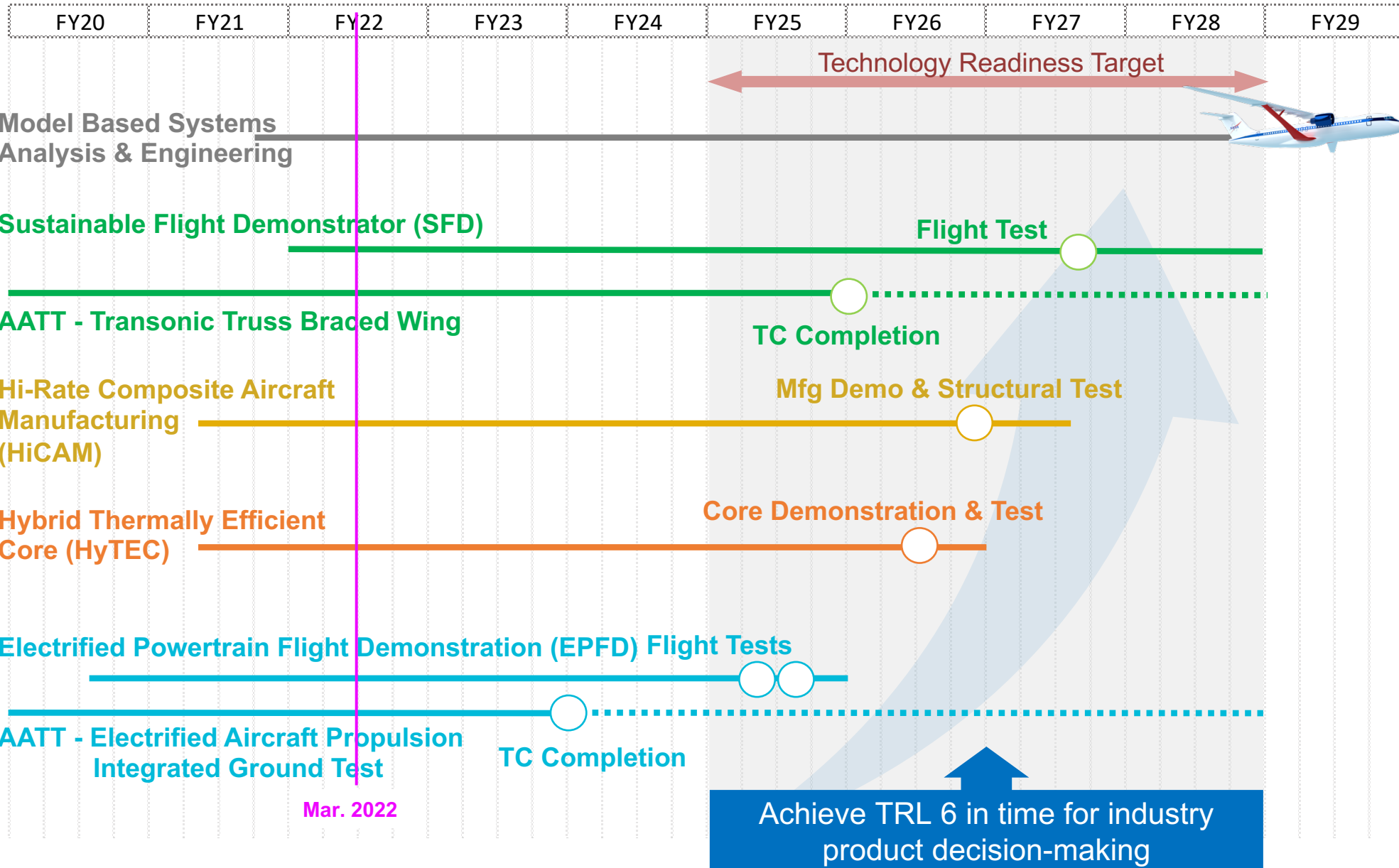
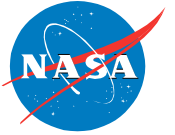
FAA CLEEN I

FAA CLEEN II

FAA CLEEN III

ARMD Subsonic Transport Strategy Based on over a Decade of Research,
Concept and Technology Development, and NASA-Industry Partnership

Subsonic Transports: Integrated Technology Development



Leverage the Asset
—
Future Spirals

Planned
Notional

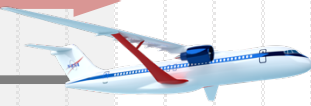
Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset

Future Spirals

AATT - Transonic Truss Braced Wing

EPFD: NASA awarded (Oct 2021) GE Aviation and MagniX USA Inc. contracts to mature MW-class hybrid electric propulsion systems & demonstrate flight readiness for single-aisle aircraft. Will identify/retire technical barriers and integration risk through spiral developments to help inform the development of standards & regulations for future EAP systems.

(HICAM)

AATT/Electrified Aircraft Propulsion: Testing underway at the NEAT Facility with industry partners in MW-class components and powertrains. Successful TRL4 demonstration of MW-class circuit breaker in partnership with Naval Postgraduate School and other circuit breaker demonstrations on track.

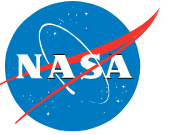
Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

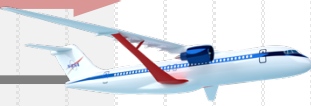
Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset

Future Spirals

- Initial competitive NASA Research Announcement (NRA) process completed. Awards made 9/2021 for small core technologies to TRL 4/5 by 2023.
- 2nd NRA solicitation was released. Proposals received/evaluated for small core combustor design/operability using 100% SAF—awards pending budget appropriations.
- Awarded NRA contracts have been kicked off with testing and hardware development underway.

AATT - Transon

Hi-Rate Composite Manufacturing (HiCAM)

Hybrid Thermally Efficient Core (HyTEC)

Core Demonstration & Test

Planned

Notional

Electrified Powertrain Flight Demonstration (EPFD) Flight Tests

AATT - Electrified Aircraft Propulsion Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

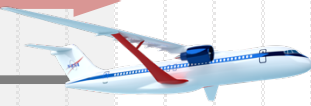
Subsonic Transports: Integrated Technology Development



FY20	FY21	FY22	FY23	FY24	FY25	FY26	FY27	FY28	FY29
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Technology Readiness Target

Model Based Systems Analysis & Engineering



Sustainable Flight Demonstrator (SFD)

Flight Test

Leverage the Asset

Future Spirals

AATT - Transonic Truss Braced Wing

TC Completion

Hi-Rate Composite Aircraft Manufacturing (HiCAM)

Mfg Demo & Structural Test

Hybrid Thermally Efficient Core (H-TEC)

Core Demonstration & Test

Planned

Notional

- Project Formulation complete; formal approval (Jan. 2022) to proceed to Implementation
 - Completed System Requirements and Baseline Definition
 - Completed Initial Technology Assessments & Roadmaps
- Integrated Product Teams being formed for Technology Development phase
 - Includes requirements definition for a full-scale, component-level test article
- Leveraging Advanced Composites Consortium (18 partners)

Elect

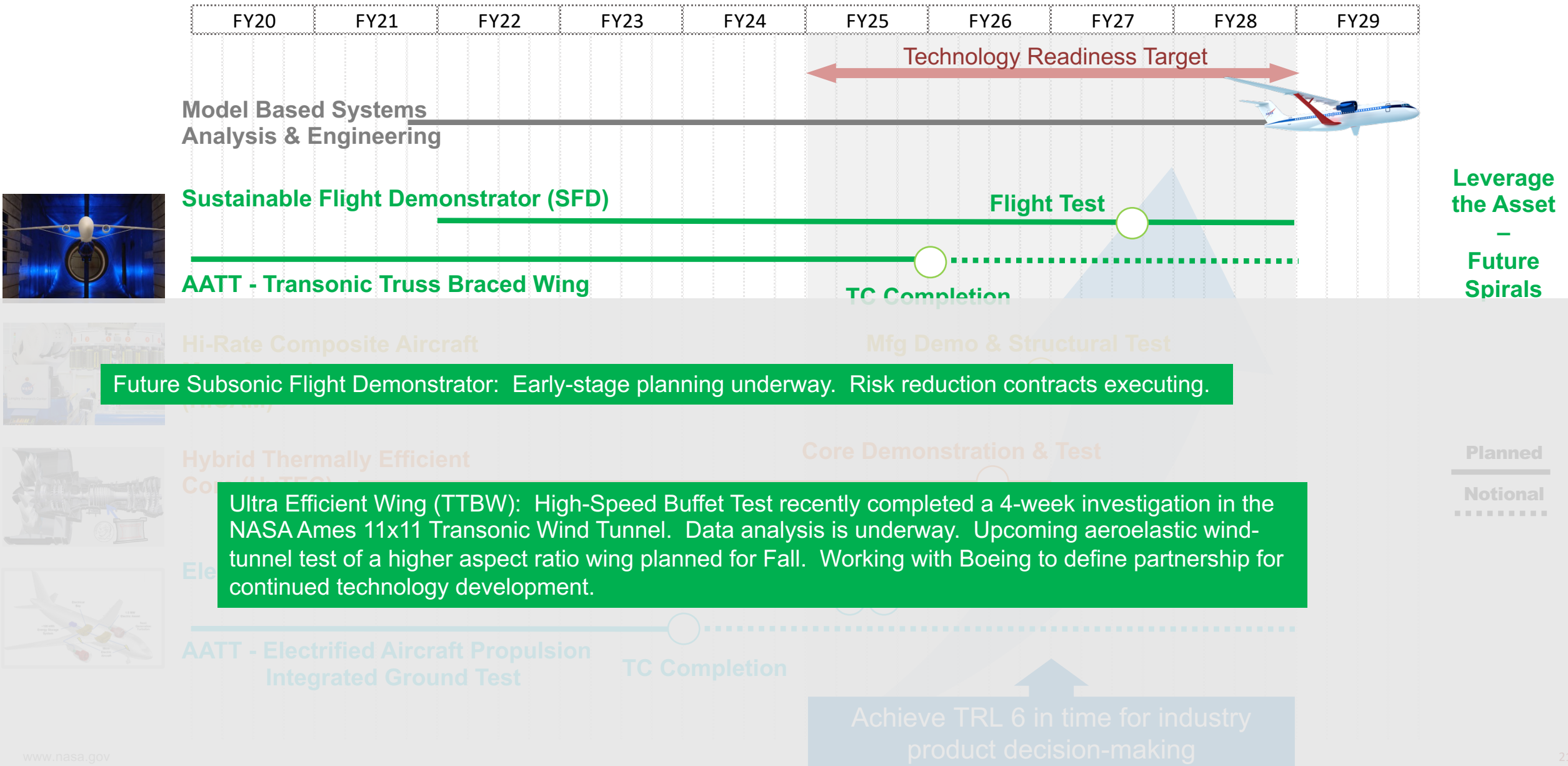
AATT

Integrated Ground Test

TC Completion

Achieve TRL 6 in time for industry product decision-making

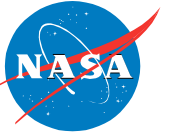
Subsonic Transports: Integrated Technology Development





Other Important Items

- Overall support from key stakeholders continues to be strong – ARMD research efforts well synchronized with FAA and are consistent with Administration environmental sustainability priorities. Accolades to FAA for the 2021 Aviation Climate Action Plan.
- Ground and flight demonstration efforts are shaping up with an eye toward advancing key technologies to TRL6.
- ARMD remains committed to maintaining a balance between foundational research and larger flight demonstrations.
- NASA Research Centers safely restarting key, mission-critical test facilities and research efforts on-site. Progress is being made – Centers are up to 50% onsite workforce limits and working toward “new normal,” hybrid operations.



Thank you